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Federal Communications Commission
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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January 31, 1992

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FCC MAIL BRANCH

Secretary, Federal Communications Commission
1919 M Street
Washington, DC 20554

Dear Sir,

Enclosed are fifteen "original" copies of my Reply Comments on the Notice of Proposed Rule in MM Docket 87-268. Please provide an individual copy to each Commissioner.

Sincerely,

William F. Schreiber

William F. Schreiber
Professor of Electrical
Engineering, Emeritus

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Federal Communications Commission
Office of the Secretary

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Before the Federal Communications Commission
Washington DC 20554

In the Matter of
Advanced Television Systems
and Their Impact upon the
Existing Television Broadcast Service

MM Docket No. 87-268
Notice of Proposed Rule Making
November 8, 1991

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Reply Comments of

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The opinions expressed herein are those of the author only.

January 31, 1992

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Executive Summary

The multiport receiver does not enhance interoperability; it impedes it by requiring all receivers to use the same scanning raster.

The words "digital" and "analog" are being misused to the extent that rational discourse about optimum systems is becoming near-impossible. All the good things that are being ascribed to digital transmission in fact are due to digital source coding and to dealing with images in the frequency domain. This docket concerns terrestrial transmission primarily. It is far from proved either that all-digital transmission, as currently proposed, helps solve the problems of terrestrial transmission or that analog or hybrid transmission precludes a solution.

Very significant progress has been made in digital terrestrial broadcasting in Europe, but is being ignored in the US. Field tests of digital audio broadcasting have already been carried out and field testing of digital video broadcasting is to start this spring. The methods used are inherently immune to multipath and do not require the use of automatic channel equalizers. A much more sophisticated channel coding method is being used than proposed in the US.

Introduction

These reply comments are directed primarily at the material on the multiport receiver contained in the comments submitted to the Commission in this docket on December 20, 1991 by the NCTA.[1] They are directed secondarily at comments by a number of others to the effect that "digital" television necessarily facilitates interoperability as well as other desirable features in a new system.

Unfortunately, the word "digital" is being used by many commentators to be synonymous with "modern," and the word "analog" to refer to all the things perceived to be wrong with NTSC. In fact, digital *transmission,* as used by four of the system proponents, does not guarantee interoperability (all four of these systems require decoding to baseband in order to be transcoding to any other format)[2] nor does analog or hybrid transmission preclude it.[3] In addition, some commentators appear to have forgotten that *the current proceeding is directed primarily to setting standards for terrestrial broadcasting,* not for cable, DBS, or fiber, which the Commission has invited to use whatever standards they believe to be in their interests.

The multiport receiver does not facilitate interoperability; rather it restricts it by requiring all displays to have the same scanning raster. If they did not, then even the multiport enthusiasts agree that the approach is impractical. Yet different scanning rasters are precisely what interoperability is all about.

There are requirements other than interoperability that are of more immediate concern to the success of a new television system; these are discussed in my earlier comments. They include spectrum efficiency, reliability, and cost. It is not at all clear that all-digital broadcasting, as currently proposed, will meet these requirements.

What *is* wrong with NTSC, and why are we going to replace it?

Extravagant use of spectrum and very poor picture quality in the home are the main reasons to replace NTSC. A secondary reason is the economic benefit that may accrue to companies and the country due to the large capital expenditures that will be required. The extremely poor performance of NTSC and similar systems in the face of typical analog channel impairments is fundamental to their system designs; it cannot be substantially improved except by changing to a necessarily incompatible system or by using a different transmission medium. This, of course, was the reason for the Commission to choose simulcasting, rather than a compatible signal format, as the better way to serve existing receivers during the transition period.

Regardless of picture quality, the very low spectrum efficiency of NTSC in the face of demands for more spectrum for mobile services gives the Commission ample reason to use an entirely new

[1]NCTA is not the author the material referred to. It was produced by the Consumer Electronics Group of the Electronic Industries Association.

[2]A recent change to the ATRC system permits the extraction of a low-resolution signal by decoding only a portion of the transmitted data. This is an excellent idea.

[3]See comments of Prof. Kenneth L. Phillips.

system. Once a new system emerges, then the principal problem will be how to implement it with minimum disruption. That is the question at issue.

How can interoperability be achieved?

There may be other ways, but a promising method is to divide the video spectrum into a set of (spatial and possibly temporal) frequency components, and to use more or fewer to form images of higher or lower resolution. These components must then be encoded in a form that permits decoders of various resolutions to accept only those components that they can use and to ignore the others. This also permits nondisruptive improvement over time. More and more components can be added at the encoder. Decoders of various vintages recover just those components for which they were designed, ignoring whatever else is transmitted. In the case of transmissions from low-resolution encoders, higher-resolution decoders will simply use zero level for the missing components, producing a picture no better than that transmitted, but displaying it on their high line-rate display.

This scheme necessarily involves joint source and channel coding and the use of multiresolution (also call hierarchical or progressive) encoders. Very good work is being done in this area by the group at Columbia University under the direction of Profs. Anastassiou and Vetterli. All-digital transmission can be used in some of these schemes.

How can be achieve high spectrum efficiency?

The rate at which information can be transmitted in the broadcast channel is proportional to the product of bandwidth and signal-to-noise ratio. It thus varies over a wide range due to operation of the inverse-square law, a range much too large to be countered with antennas. If we define spectrum efficiency as the number of different programs of a given picture and sound quality that can be delived to each viewer within an overall spectrum allocation, then it is absolutely required for maximum efficiency that *all* the capacity at each receiver be utilized. This precludes the delivery of the same data rate to all receivers, as the currently proposed digital systems do.[4] A soft threshold of this type is inherent with analog or hybrid analog/digital systems, and can also be achieved in digital systems, but not by the currently proposed methods.

How about reliability and coverage?

Digital systems do not overcome channel impairments; channel impairments must first be overcome in order to permit digital transmission at any reasonable rate. They also have a sharp threshold, so that service will come and go at random when signal conditions are just barely acceptable. All current digital system proponents plan to use automatic channel equalizers, sophisticated versions of ghost cancellers proposed for improving NTSC, for dealing with these impairments. In their calculations of service area, all proponents are assuming that the channel equalizers will work so well that the raw bit error rate will not be increased under even the worst conditions of

[4]The AT&T/Zenith system and the ATRC system have recently be modified to deliver a lower data rate beyond the region where no service at all would be provided with constant data rate. This is a step in the right direction, but it does not deal with the issue of closer-in receivers (most receivers are closer-in in most cities. I believe where the channel capacity may be 2 or 3 times higher than in the fringe areas.

dynamic multipath and interference. Needless to say, such performance has never been demonstrated, and therefore must be proven to be achievable with practical receivers. It may not even be properly proven by field testing unless the field tests are carried out in large cities with typically bad impairments.

The European experiments on digital audio broadcasting seem to be mostly unknown in the US. In DAB, a very sophisticated channel coding scheme called Coded Orthogonal Frequency Division Multiplex is being used. The basic principal is that the spectrum is divided into a large number (500 or more) of subchannels in which the symbol length is longer than the spread of the echoes. Thus all echoes arrive within one symbol length and add rather than interfere with each other. Field tests of the audio system have been carried out in Europe and in Canada. Field tests of a video system based on the same principles will start this spring by the National Transcommunication Laboratories (part of the old IBA) of Winchester, UK. As has been proved by extensive field tests, these systems are inherently immune to multipath, both fixed and moving, and do not require a channel equalizer. They can also be made virtually immune to NTSC interference simply by not using subcarriers close to the NTSC picture and sound carrier.

From work now going on at MIT, I believe that the COFDM scheme can be improved by the use of spread spectrum. This would permit the attainment of a soft threshold and optimum distribution of noise among the frequency components, as well as multipath immunity least as good. It can be implemented by all-digital as well as hybrid methods.

Conclusion

The misunderstanding of the advantages and disadvantages of all-digital transmission is standing in the way of an expeditious solution to the problem of finding terrestrial transmission standards that will meet the needs of the Commission, broadcasters, and viewers. As a first step, all parties should thoroughly familiarize themselves with European experience is digital broadcasting, which is far in advance of our own. Likewise, the question of interoperability must be examined at a more fundamental level than it has been so far if we are to find a solution that will satisfy non-broadcasting applications without unduly penalizing broadcasters and viewers.